

INTERFACE PROBLEMS BETWEEN MEDICINE AND COMPUTERS

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Some major interface problems in medical informatics in the United States are: Unique patient identification code, patient privacy rights and confidentiality of the medical record, dealing with natural language, electronic representation of medical information, electronic multi-generation patient records and knowledge bases. These problems are reviewed.

In health care, computers were used initially as powerful calculators for clerical tasks such as patient billing, inventory, or payroll. Gradually, it became apparent that these machines could perform much more sophisticated roles by serving as an external knowledge base extending the physician's memory, or by performing intelligent functions while assisting in clinical decision making. However, progress in this area was delayed because clinical medicine was ill-prepared to interface with high-technology: A "medical interface" was required which could transform the human-oriented clinical data into machine-compatible symbols.¹ The purpose of this discourse is to review some interface problems which must be resolved before medical informatics can evolve freely.

Unique Identifications

In the preautomation "Gutenberg era", adequate patient identification involved accurately recording the patient's full name, date of birth, and address. The evolution of large electronic clinical case history banks serving a mobile population and the growing recognition of the need for complete longitudinal life-long illness records make our traditional personal identifiers increasingly inadequate. (The risk of two patients with the same name and birthday will increase.) Further, to satisfy the needs of modern clinical genetics, computers should be capable of assembling multi-generation family pedigrees. To switch from the Gutenberg era to the electronic era, patients and their blood relations as well as physicians, other health care providers, and health

care institutions must all be uniquely and uniformly identifiable. All this is required intrinsically by the technology in order to keep filing errors under control. Social Security numbers are possible identifiers, but they may not be the best identifiers. Children do not have numbers and some people have more than one number. Further, the Social Security number would connect the patient records with various administrative systems such as the Internal Revenue Service which already uses these numbers. This would make medical privacy easy to violate. The time seems right to begin a purposeful joint national planning for a system of medical identification. The planning can be initiated by medical informatics and must involve the medical community, the health insurance system, consumers, and government.

Right to Privacy and Medical Informatics

Concurrent with the introduction of unique identifiers, a pragmatic, technically competent and morally responsible formal planning effort should be launched to protect the right to privacy of the patient and the entire health care industry in a computerized environment. Early efforts of the Society for Computer Medicine in the 1970s² resulted in a set of ethical guidelines and operational codes but these activities were not followed up by protective legislative regulations. Incidences of unauthorized access to electronic medical records appeared recently in the daily newspapers. This has sensitized the medical community as well as patients. Convincing evidence will be needed to prove that electronic disease records will remain confidential. It is proposed that a coordinated national effort be initiated in order to resolve this difficult problem.

Natural Language Input/Output

Accepting natural language input, and generating natural language output is sine qua non for a physician-machine synergism.³ The semantic content in natural language medical text is carried primarily by the medical terms, but it is also affected by

the modifier(s) and the significance of the syntactic structure. All three information-carrying elements must be extracted from the natural language input, without loss or distortion of the implicit information content. Thus, the task of the medical interface must transform the unrestricted text into symbols of a highly standardized formal language. All this cognitive processing and transformation should be done rapidly. A successful interface should make the user perceive the computer as a Turing machine³ which "knows" medicine.

Representation of Medical Information

In the computerized clinical case history, as well as in various machine-based knowledge-bases, a single fact is the smallest unit of information. In technical terms, a fact in the computer is a standardized node-arc combination.³ To the clinician, such a fact is the smallest (molecular) form of knowledge, a single unit of information which is believed to be true. A fact may be nested in natural language text, or expressed as a numeric value, an analog signal or a picture. Accurate electronic representation of these various forms of the facts requires sharp delineation of the nodes and arcs. The nodes are the terms of the medical nomenclature; they should not only be quantified and standardized, but also classified and systematized by enumerating the various recognized semantic relationships among these terms. We have demonstrated that such a cognitive network of facts (a network of nodes and arcs) can fully represent the current status of medical knowledge. The modifiers in natural language also require semantic explication and semi-quantification. Special attention should be given to abbreviations, unambiguous representations of chemical entities, and laboratory results. All these must be accomplished by national consensus.

Patient Records

Computers offer two fundamentally new dimensions to clinical medicine. One is the machine's economical storage capacity for large numbers of clinical case histories in an instantly retrievable mode. The other is the ability for automated record linkage to create longitudinal records instead of our present episode-oriented documentation system. To exploit these two capabilities, electronic patient care documentation should evolve at all health care delivery sites, (such as hospitals, medical offices, nursing homes, and health departments) and the data should be linked and integrated. This is a medical desideratum and an economic imperative.

In our experience, such a longitudinal

clinical case history bank is a surprisingly rich information source, with remarkable value to the patient, the health care system, and the science of medicine. Combination of similar patient records reveals, for the first time, natural case histories as patterns of clinical course over time. Clinical medicine has only recently recognized the definitions of risk such as high risk pregnancy, or cardiac risk factors. Large electronic case history banks offer a new opportunity for the discovery of longitudinal correlations among clinical entities. For example, clinical courses of chronic diseases and true values of various surgical and drug therapies will be re-evaluated on the basis of large numbers, long-range outcomes and multi-generation patterns.

The evolving possibility of longitudinal electronic patient records calls for re-examination of the utility of the various data elements. Some parts of the typical narrative such as patient complaints, recent case history, or progress notes, seem to have a shorter utility span, whereas all the diagnoses, diagnostic findings, drugs, surgeries, occupational exposures, and key social data seem to have long-range utility. To illustrate this point, we found that in an electronic patient record any changing in drug therapy is important information. If a particular drug is discontinued, this may indicate problems either with its therapeutic benefits or with an adverse reaction. In a large clinical case history bank, such drug information can be readily discovered and benefit/risk ratios can be calculated accurately.

A natural extension of longitudinal patient records is the concept of multi-generation record linkage. The clinical records of the parents and siblings should be linkable to the patient's record. This would greatly enhance the clinical effectiveness. The technology is readily available for multi-generation patients records, and there is ample research in this area to prove its feasibility. Moreover, electronic patient care documentation has become highly cost-effective. A new generation of clinical record administrators will be needed to serve as "brokers" of the patient data to legitimate users and to protect the right to privacy of all parties involved. National plans should be developed to train computer controlling data administrators who can maximize the benefits, and minimize the risks of using this new and powerful technology.

Electronic Knowledge Bases

When MEDLARS was designed, a specially trained librarian was placed between the literature databases and the users. This librarian can now be replaced by the

medical interface.³ In the area of computer-based clinical knowledge banks, the main progress-limiting step is the lack of an automated medicine-computer interface. The physician's memory and thought processes must be fully congruent with the information structure of the electronic knowledge bases. High fidelity transformation of natural language input by the medical interface should achieve the full congruency between the clinician user and the electronic knowledge bases. The development of an adequate medicine-computer interface is a most urgent task for medical informatics. The potential value of various knowledge banks, current literature banks, expert reviews of recent advances, and expert protocols for diagnosis/therapy are apparent. Although successful prototypes exist,⁴ a large-scale medical information network does not yet exist. Interestingly, the impact of similar knowledge bases outside of medicine have proven the immense value of instant answer capability. This author believes that such knowledge bases, combined with large, statistically preprocessed clinical case history banks will unleash the vast potential of computers for medicine.

Technically, the construction of a medical Turing machine is well within our current capabilities. A prototype has been already fieldtested.⁴ In the United States, full computerization of patient records and medical knowledge will be achieved, probably in the late 1980s. It is the author's hope that large-scale computerization will occur after the legislation of a good, purposeful national medical privacy act.

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